

Data Storage

2's Complement Notation to Store Numbers

2's Complement Notation

Integer

Representations

- ✓ fixed number of bits to represent each value
- ✓ Normally 32 bits are used
- ✓ We will discuss smaller examples for demonstration purpose

2's Complement Notation

Integer

✓ **Representations**

- ✓ For +ve integers,
Starting from zero going upward until a single zero is reached followed by all 1s
- ✓ For -ve integers,
Starting from all 1s going downwards until a single 1 is reached followed by all 0s.

a. Using patterns of length three

Bit pattern	Value represented
011	3
010	2
001	1
000	0
111	-1
110	-2
101	-3
100	-4

2's Complement Notation

Integer Representations

b. Using patterns of length four

Bit pattern	Value represented
0111	7
0110	6
0101	5
0100	4
0011	3
0010	2
0001	1
0000	0
1111	-1
1110	-2
1101	-3
1100	-4
1011	-5
1010	-6
1001	-7
1000	-8

2's Complement Notation

Conversion between +ve and -ve representations

- ✓ Start from right most bit start copying until 1st 1 arrives, after that complement all numbers.

b. Using patterns of length four

Bit pattern	Value represented
0111	7
0110	6
0101	5
0100	4
0011	3
0010	2
0001	1
0000	0
1111	-1
1110	-2
1101	-3
1100	-4
1011	-5
1010	-6
1001	-7
1000	-8

Addition in 2's Complement Notation

- ✓ All rules are same except that all bit patterns, including the answer, are the same length
- ✓ Truncation is performed

Problem in base 10		Problem in two's complement		Answer in base 10
$\begin{array}{r} 3 \\ + 2 \\ \hline \end{array}$	→	$\begin{array}{r} 0011 \\ + 0010 \\ \hline 0101 \end{array}$	→	5
$\begin{array}{r} -3 \\ + -2 \\ \hline \end{array}$	→	$\begin{array}{r} 1101 \\ + 1110 \\ \hline 1011 \end{array}$	→	-5
$\begin{array}{r} 7 \\ + -5 \\ \hline \end{array}$	→	$\begin{array}{r} 0111 \\ + 1011 \\ \hline 0010 \end{array}$	→	2

Problem of Overflow

- ✓ Using 4 bits, maximum +ve number 7 can be represented and -8 on the -ve side.
- ✓ $5+4 = 9$ which can not be stored in four bits
- ✓ Result would be as -7.

b. Using patterns of length four

Bit pattern	Value represented
0111	7
0110	6
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Problem of Overflow

- ✓ Today's computers have longer bit patterns normally 32 bits
- ✓ Maximum positive value = 2,147,483,647
- ✓ If still overflow occurs, we can use even more bits, or changing the units like calculating answer in Km than meter.

Dangers of using Computer

- ✓ Previously 16 bits were used to store 2's complement notation, maximum number represented was 32,768
- ✓ On September 19, 1989, Hospital system malfunctioned as 32, 768 days had been passed after January 1 1900, thus it produced negative value.

Summary

2's

✓ Complement

Representation of +ve and -ve numbers

✓ Conversions

✓ Addition in 2's complement

✓ Truncation error

✓ Overflow